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A Forest FIRE Research Program for the Lake States

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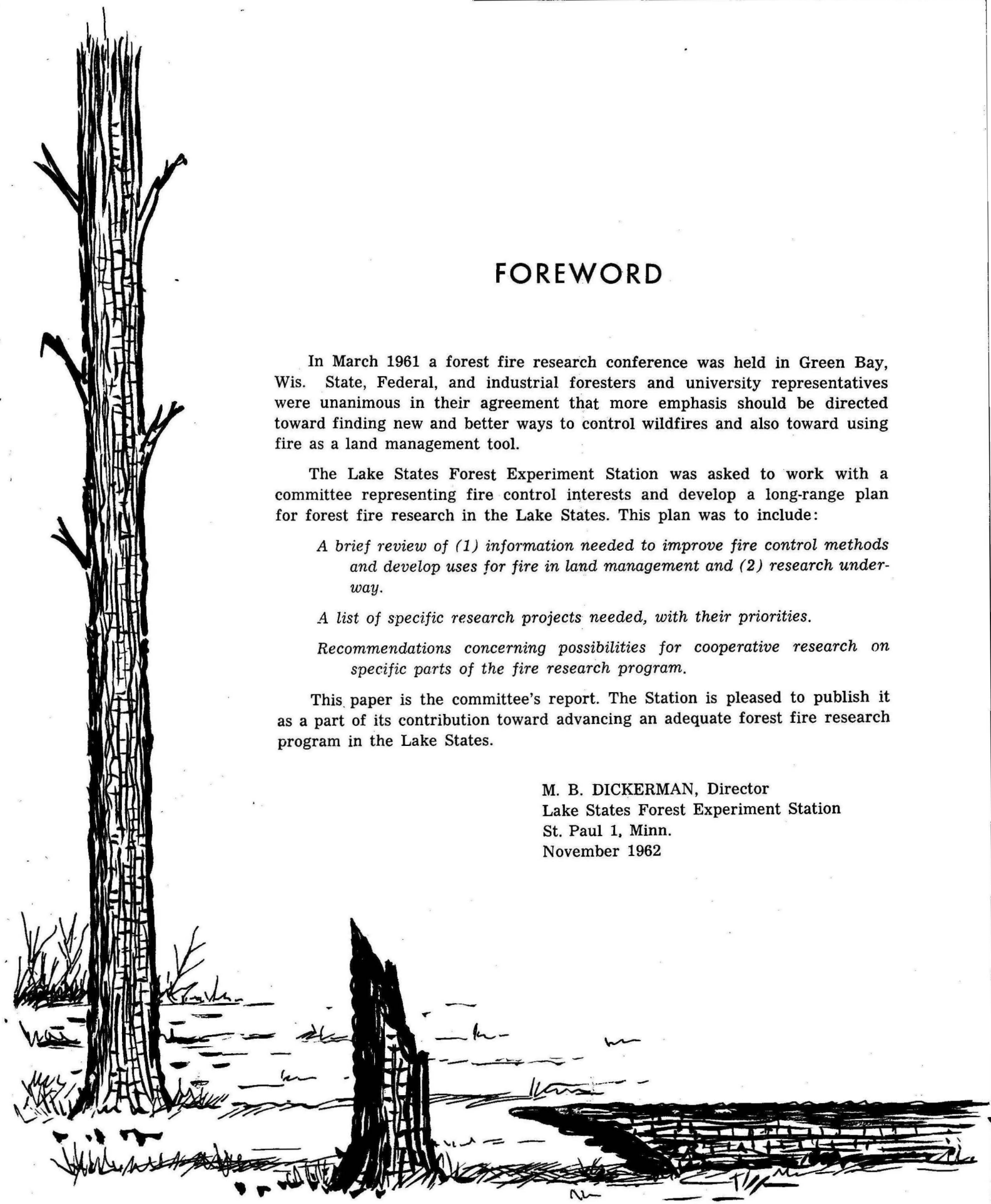

FOREWORD

In March 1961 a forest fire research conference was held in Green Bay, Wis. State, Federal, and industrial foresters and university representatives were unanimous in their agreement that more emphasis should be directed toward finding new and better ways to control wildfires and also toward using fire as a land management tool.

The Lake States Forest Experiment Station was asked to work with a committee representing fire control interests and develop a long-range plan for forest fire research in the Lake States. This plan was to include:

A brief review of (1) information needed to improve fire control methods and develop uses for fire in land management and (2) research underway.

A list of specific research projects needed, with their priorities.

Recommendations concerning possibilities for cooperative research on specific parts of the fire research program.

This paper is the committee's report. The Station is pleased to publish it as a part of its contribution toward advancing an adequate forest fire research program in the Lake States.

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November 1962

THE LAKE STATES COMMITTEE ON FOREST FIRE RESEARCH

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A crown fire in plantations or well-spaced conifer stands is a spectacular and awesome sight. It usually leaves complete devastation in its wake. In the bottom picture, all the trees have been killed. Some wood may be salvaged, but a large part of the anticipated financial returns has been lost. (Pictures courtesy of (*top*) Francis Horrigan, Park Rapids Enterprise, Park Rapids, Minn., and (*bottom*) Minnesota and Ontario Paper Co.)

INTRODUCTION

Changing conditions in the Lake States over the past several decades are increasing both the likelihood of fires starting and the intensity with which they burn. As our second-growth forests mature, additional cutting is creating large amounts of slash, an ideal fuel. More use of the forests for recreation is bringing with it more risk of fire, for a large proportion of fires in this region is man-caused. Land area in conifer plantations is increasing. These areas are particularly susceptible to fire from the time they are planted until they are harvested.

Conifer plantations (and indeed, any well-spaced, even-aged conifer stands) present an especially difficult fire control problem. Under certain conditions, the fire leaps easily into the crown, burns fiercely, and spreads with fantastic speed. Such fires can destroy large acreages of valuable timber stands within a few hours.

Many factors combine to create a crown fire situation. Each of these factors needs concentrated study to better understand the crown fire and provide measures for its prediction and control. Fuel moisture and fuel volume studies, as well as more complete information on fire spread, will help indicate a buildup of adverse conditions leading to possible crown fire occurrence. Improved fire weather forecasting will provide warnings to specific areas when weather conditions are right for crown fires. When we are able to identify accurately these potential crown fire situations, the control job will become easier and fire prevention more effective.

A successful method of attack on crown fires can be developed only if the important factors responsible for their occurrence and instrumental in their control are understood. The crown fire is a product of *fuels* and *weather*, and its behavior is primarily dependent upon these two factors. The difficulty comes in identifying more specifically when conditions are right for a fire to move through the tree crowns as an independent, running fire and then in devising means of *control*. Fuel, weather, and fire control studies will add greatly to our ability to cope with any type of forest fire; but they are especially urgent because of the increasing occurrence of fast-moving, destructive crown fires.

In addition, new approaches are needed toward fire *prevention*. The studies proposed here are directed mainly toward the areas of fire prevention dealing with enforcement and education.

Finally, investigations are needed in *prescribed burning*. Some work is already being done in the Lake States; but many additional studies are needed, particularly in the use of fire for hazard reduction and pine regeneration.

Thus the important fields of research discussed in this paper are forest fuels, weather-fire behavior, fire control, fire prevention, and prescribed burning.

In this review of fire research needs, specific projects are listed that should be started, continued, or expanded to meet the increasing requirements of forest land managers. The proposals are a composite of the views of forest research workers, fire control specialists, and land managers. The material has been assembled to assist the men responsible for planning and financing fire research. Suggestions also are made for effective pooling of skills and information by men in the universities, conservation departments, and the U.S. Forest Service. Since additional resources beyond those now available are a necessary feature of satisfactory fire research, special attention has been given to screening program proposals and to achieving economies by making full use of the facilities and skills of each participating agency.

The degree of hazard presented by logging slash depends on many factors, among them size, quantity, and arrangement of the material. Most important, however, is fuel moisture content. The drier the fuel, the more likelihood of a fire starting and the more difficult it is to control. The slash in this picture is the result of an unusually heavy experimental cutting. It is still green, but with a few weeks of sun and wind fuel flammability will increase rapidly.

To predict fire behavior and intensity, the volume of fuel per unit area must be known. Here sample tree crowns are weighed and related to basal area of the stand. With sufficient data of this kind, a table can be prepared showing the volume of slash that may be expected in a given stand when it is thinned back to a predetermined basal area.

The logging slash produced by a commercial thinning in this red pine plantation may provide the fuel along the edges of the stand to carry a fire into the tree crowns. Since crown fires present the most difficult control problem in the Lake States, it is important to know the amount of fuel in the standing trees. Measurements such as those shown in the middle picture also provide a means of estimating the fuel in standing trees.

FOREST FUELS

Information Needed and Research Underway

The very nature of forest fuels makes them difficult to measure, analyze, and relate to expected forest fire behavior. Each square foot of ground covered by combustible material presents a somewhat different problem; and although much progress has been made in classifying these fuels into broad types, a great deal more must be done before fuel-fire relationships can be predicted with reasonable accuracy.

There are several fuel factors that determine how a fire will start, spread, and do damage. Fuel size and arrangement, moisture content, fuel weight per unit area, and chemical composition — these all combine to influence ignition, rate of spread, fire behavior, and fire intensity. Each of these individual factors is difficult to describe in quantitative terms; and when they are thrown together, as they are in a natural fuel complex, the problem is compounded.

The single factor that fluctuates most widely over a range of values and from one time and place to another is fuel moisture. If the moisture content of the fuel is high enough, fires will not burn regardless of variations in the other factors. On the other hand, if fuel moisture is low, other factors become more prominent in determining just what fire behavior might be expected and what suppression action is necessary.

In 1958, a publication was issued by the Lake States Forest Experiment Station on fire fuels in red pine plantations.[1] Estimates of fuel volume (weight per acre) in red pine plantations that varied by age and site were presented. Dead branchwood on the lower portion of the trees and needle litter were the two predominant fuel types measured.

More recently, a fire research project has been started that will provide additional estimates of fuel volume. This project is concerned with developing methods and techniques for estimating the total weight of fuel on land units that vary by species composition, site, and stand characteristics. Included will be descriptions of fuel size, distribution, and arrangement. The studies have so far been limited to red and jack pine plantations, but should be extended to include commercially important conifer stands, mixed pine-hardwood stands, and possibly pure hardwood types. The basis for these weight estimates is measurement of individual tree crowns. Green weight is converted to dry weight, and the dry weight values are applied to limited stand areas. Being able to determine the total fuel weight in various stands will greatly facilitate fire behavior predictions in those stands.

Fuel moisture conditions in a forest stand vary by stand condition or characteristics and by weather, both cumulative and current. In the summer of 1961, the Lake States Forest Experiment Station began fuel-moisture studies in two plantation areas near Cadillac, Mich. The objective was to determine fuel moisture variations in green and dead material for thinned and unthinned stands of red pine and to relate these variations to forest cover, cumulative weather factors, and current weather changes. Results will be useful in developing a means of predicting the moisture content of forest fuels in the open, in partially cut slash areas, and in uncut plantations. The flammability of these areas appears to be directly related to fuel moisture content.

The University of Michigan, Department of Forestry, is presently engaged in a study of fuel description and measurement in cooperation with the Lake States Forest Experiment Station.

Research needs in forest fuels include an additional study that may have a bearing on crown fire occurrence although it has to do chiefly with regular fire occurrence, behavior, and control. It concerns logging-slash deterioration and the importance of slash fuels in forest fire planning. There appears to be little agreement as to how rapidly slash fuels deteriorate or break down from a highly flammable to a relatively safe condition. If there are significant differences between species or areas in rate and degree of decomposition, these differences should be explained in terms of physical or chemical characteristics of the specific fuels. Certain species appear to be more susceptible to rotting fungi; other species become less flammable as they drop their needles and fine twigs.

[1] *La Mois, L. M. Fire Fuels in Red Pine Plantations. U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 68, 19 pp., illus. 1958.*

Questions that should be answered are: How rapidly do logging-slash areas become relatively safe from a flammability standpoint? Can we better afford to provide intensive protection for an area for 2 or 3 years or dispose of the hazard as soon as possible after logging? Is there a financial advantage in disposing of slash and returning the area to a productive state the following year? Is there a feasible method for treating logging-slash on the ground under plantation canopies where pulpwood cuttings have been made?

The chemical characteristics of forest fuels are closely tied in with both slash deterioration and fuel flammability. Certain chemical compounds in forest fuels make them more resistant to decay and at the same time more flammable. If some tree species are more flammable than others, they should be identified and managed accordingly.

Proposed Studies •

1. *Extend fuel volume studies to include fuel weight measurements* on all the commercial forest types that pose a fire threat. Litter, surface plant communities, dead branchwood, and living tree crowns should be included in this survey of fuel weights. Fuel accumulation studies should be started to help determine the weight of surface fuel available from year to year. Eventually methods should be developed to estimate total available fuel in pure conifer, pure hardwood, and mixed conifer-hardwood stands.

2. *Continue studies of fuel moisture in both living and dead material* to provide a better understanding of the relationships between current and cumulative weather and the moisture content of forest fuels. This work should be correlated with the fuel-weight studies to yield the maximum in fire behavior data.

3. *Establish a study of slash deterioration* to determine the rates of decomposition for the various commercial coniferous species. This study should include both visual observations and physical measurements of slash condition as affected by fuel type, climatic conditions, cutting practice, and stand condition. Variations in chemical content of forest fuels may influence both rate of decomposition and flammability. If large differences are evident in the rates of deterioration, the chemical makeup of these fuels should be analyzed.

4. *Determine specific values for flammability and rate of fire-spread* for Lake States fuels. The new forest fire laboratories of the Forest Service offer a means of burning representative fuels in the laboratory where fuel moisture, air temperature, relative humidity, and wind velocity are held at specified levels.

Special Considerations and Opportunities for Cooperation

Fuels research is a part of the regular program at nearly all Forest Service experiment stations and is well coordinated on a national basis. This coordination makes it possible to try new ideas and techniques developed in other areas to see how they apply to local conditions; likewise, methods developed in the Lake States can be tried in other parts of the country.

Cooperative efforts could contribute much to the advancement of fuel studies. Forestry agencies in all States could help in locating and establishing areas to be used for slash deterioration studies. The various commercial forest types should be represented as well as stands having different exposures and levels of cutting. Fuel accumulation studies can more effectively cover large areas if the periodic measurements can be made by individual cooperators. Litter traps could be exposed where cooperators could conveniently weigh the contents of the traps once or twice a year. The data would be summarized by forest type, stand density, site, and possibly other variables.

WEATHER-FIRE BEHAVIOR

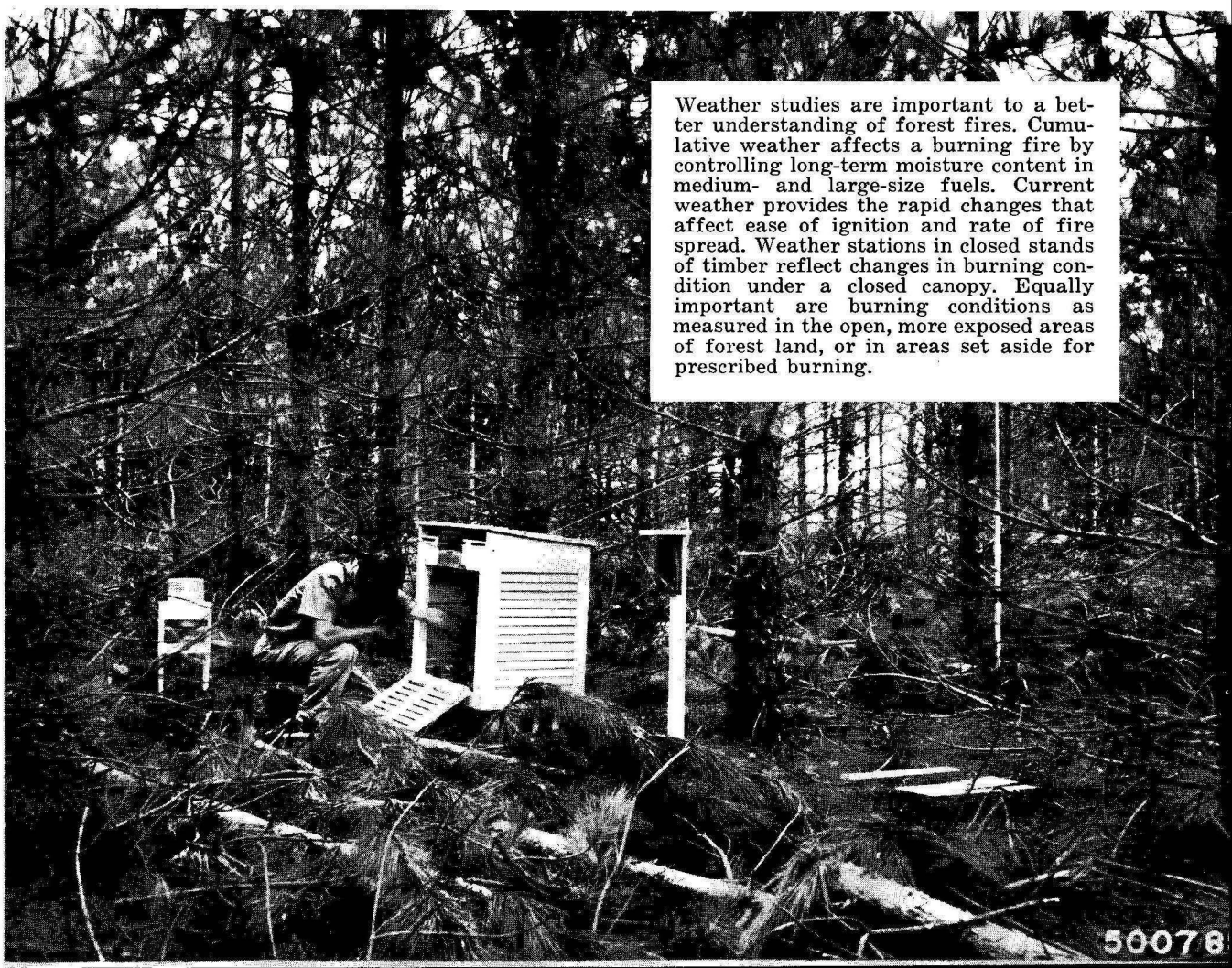
Information Needed and Research Underway

Weather is the controlling factor in most Lake States fires. Cumulative weather dictates long-term moisture conditions in soil and the larger fuels; current weather adds the day-to-day variations in atmospheric conditions that cause normal or unusual fire behavior. When a fire is blowing up and burning large acreages, it is relatively easy to measure the current weather factors to better understand such violent fire action. More difficult is the job of identifying in advance the critical levels of fuel moisture, relative humidity, and wind velocity and then forecasting when these conditions will occur. Establishing these critical levels is a job for the forester — forecasting these values is a job for the U.S. Weather Bureau Fire Weather Forecasting Service.

Currently several projects involve research in fire-weather forecasting. These are under the direction of the U.S. Weather Bureau and are designed to find out more about certain aspects of weather that affect fire ignition and spread.

It is the responsibility of all fire control agencies using fire-weather forecasts to make sure that the field measurements taken at fire-danger and fire-weather stations are as complete and as accurate as possible. These weather reports that originate in the field provide the basic weather data for a daily summary of fire weather. The field reports are one of the primary sources of information available to the fire-weather forecaster for making his daily forecasts.

A new system of rating forest fire danger is currently being tested in the Lake States. The first phase of this multiple-index system includes a Buildup Index for evaluating moisture deficiencies and a Spread Index for rating current fire behavior. The test stations located in Minnesota, Michigan, and Wisconsin will help iron out some of the operational problems in putting the system



Weather studies are important to a better understanding of forest fires. Cumulative weather affects a burning fire by controlling long-term moisture content in medium- and large-size fuels. Current weather provides the rapid changes that affect ease of ignition and rate of fire spread. Weather stations in closed stands of timber reflect changes in burning condition under a closed canopy. Equally important are burning conditions as measured in the open, more exposed areas of forest land, or in areas set aside for prescribed burning.

to practical use. Eventually, the improved system will replace the current Lake States meter. Experience and continued testing will help determine how the new danger rating system can be used most effectively for adjusting fire-suppression manpower requirements.

We need a continued reappraisal of the weather conditions under which fires start and spread. When the new danger rating system is adopted, burning conditions and fire weather will necessarily have to be interpreted in terms of Buildup Index and Spread Index. To do this, the occurrence, behavior, and ultimate size of forest fires must be analyzed in relation to the new system of danger rating.

Proposed Studies •

1. In cooperation with State and Federal forestry organizations, *develop a means of interpreting fire-weather measurements* in terms of fire preparedness, suppression activity, and expected damage. This will require a careful analysis of fires, both past and current, in relation to fire weather — specifically Buildup Index and Spread Index.

2. Continue cooperative work of the State and Federal protection agencies and the U.S. Weather Bureau fire-weather forecaster to *improve*: (1) *the quality of weather measurements* made for fire-weather purposes and (2) *the interpretative use of fire-weather forecasts.*

3. In cooperation with the State protection agencies, *devise a uniform method of securing weather information on all Class D and E fires* (Class D fire, 100-300 acres burned; Class E fire, over 300 acres) that burn predominantly in timber land. This would involve recording specific weather factors during the course of the fire, the ultimate size of the fire, and the prevailing fuel types on the fire. This information is now available on all class E Forest Service fires through a required fire behavior report.

Special Considerations and Opportunities for Cooperation

The role of forest fire research in connection with fire weather is to help bridge the gap between research of the U.S. Weather Bureau and application by fire-control agencies. Cooperative efforts of several groups are required for successful translation of fire weather information into estimates of fire behavior in specific fuel environments. Adequate and uniform records of protection agencies are essential to the success of this work.

FIRE CONTROL METHODS

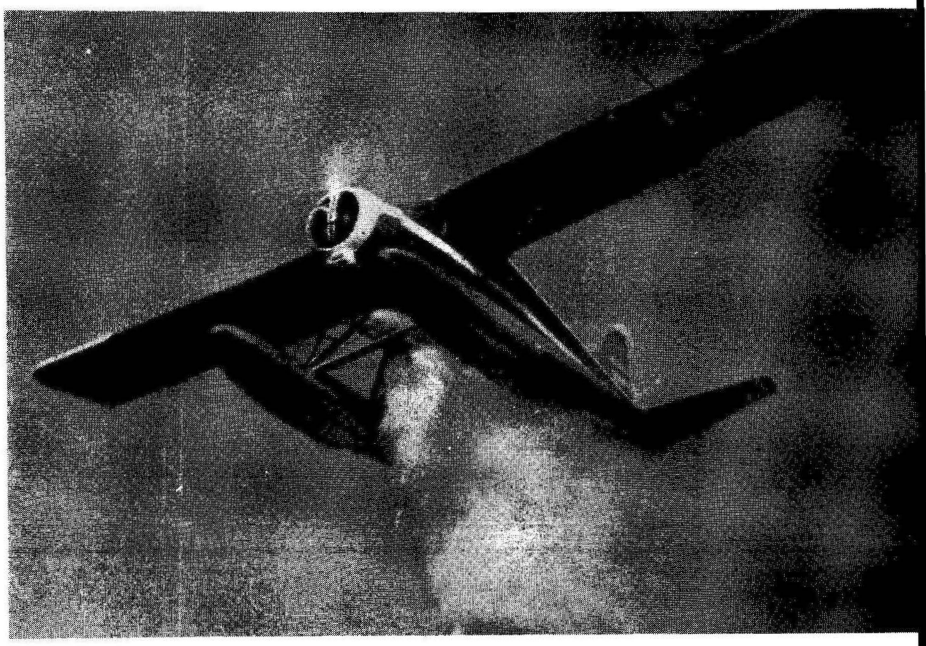
Information Needed and Research Underway

Each year new equipment, materials, and techniques are developed to make fire control more efficient and economical. These new developments must be tested to determine if they measure up to the present standards of performance for similar equipment presently in use. These tests must be made in the light of present conditions as well as of expected changes in the future. A fire control method that appears impractical by present-day standards may receive wide acceptance when tested or used under the same conditions in the future. The use of aircraft in fire control is a good example of this situation.

Most needed in the Lake States are more effective methods of fire control with particular emphasis on the suppression of crown fires. It is unlikely that a single method will be devised to control a running crown fire, but it may be possible to use a number of methods that, in combination, will do the same job.

Two factors limit acceptance of a new method or technique of fire control. They are cost and reluctance to change. Frequently this resistance or reluctance to change from an established method of fire control to an equally well-proven new method is dictated by the cost of converting from one system to another. Improvements in fire con-

Specialized fire control equipment is needed to further reduce the number of fires and area burned in the Lake States. Testing and evaluation of new equipment are important steps in its development for operational use.
Minnesota and Wisconsin are using the Bombardier for fighting fires in wet swampy areas where it is difficult to use men and equipment. This machine can transport men across such areas and pump water directly on going fires.



Water bombing is a standard method of initial attack on National Forest lands in northern Minnesota. The DeHaviland Beaver aircraft can make frequent trips between the lake water source and the fire and release 125 gallons of water to slow down or extinguish the fire.

Casting large quantities of sand to control fires is a new principle being tested in Michigan. The Sandcaster shows real promise in controlling wildfires in all but the rocky soil types. The machine can vary the sand trajectory and can move 3 to 5 cubic yards of sand per minute in a steady 70-m.p.h. stream. (Photo courtesy of Michigan Department of Conservation.)

trol methods frequently must wait on changes in economic conditions before they can be put into use. It is the job of research to keep ahead of these changes and provide new fire control methods and techniques for subsequent testing.

Very little new fire control equipment has been developed during the past 10 years. Plows, cats, trenchers, and handtools continue to be used extensively. The Michigan Conservation Department has been developing a sandcasting machine that shows a great deal of promise for controlling fires in sandy country. Preliminary tests indicate that the machine may be used effectively under a variety of fire situations and may be an effective tool against crown fires.

Use of fire retardant chemicals for control of wildfire has been tried only on a limited scale in the Lake States. Aerial application has, for the most part, been too expensive; and ground application of promising chemicals required expensive modifications of equipment. The screening and initial testing of new fire retardant chemicals are a part of the research program at two Forest Service experiment stations. This effort should not be duplicated in the Lake States. Instead, research should help with the field testing and evaluation of fire suppression chemicals recommended for use by those experiment stations involved in fire retardant research.

Another area where additional research is needed is in the construction and maintenance of firebreaks. There is general agreement that firebreaks are used most effectively for containment purposes. That is, the breaks are usually constructed close to the expected fire source so that the fires, if they start, will be stopped before they develop an active front. Firebreaks used to break up large forested areas are seldom effective for independently stopping the spread of fire. However, these breaks are valuable in providing both quick access into an area and a prepared line from which to backfire and patrol for suppression purposes. But fire control organizations have learned not to rely too heavily on prepared firebreaks alone during periods of high fire danger. The continued use of firebreaks revolves around the following considerations:

1. Should hardwood firebreaks, both prepared and natural, be given more attention in breaking up large fuel areas?
2. Can chemicals be used economically and effectively to maintain "containment" firebreaks in a vegetative-free condition?
3. What types of firebreaks are best suited for the various cover types and fire situations found in the Lake States?
4. Is it possible to draw up some specifications that could be used as a guide in constructing, improving, and maintaining firebreaks in specified areas?

Firebreaks are maintained, to a greater or lesser extent, by nearly all protection agencies in the Lake States. No one agency is fully prepared to answer the question: "How much protection are you buying while maintaining these breaks; and how do you determine where the breaks should go, how wide they should be, and how they should be maintained?"

Research is needed to provide answers to these questions. The problem is essentially one of economics — how much money can be reasonably expended to contain fires, stop them from spreading, or to provide a starting point for control action once a fire has gotten underway.

Frequently a 12-foot-wide strip of barren ground is the only initial fire protection against a carelessly thrown match along a traveled roadway. The firebreak systems in the Lake States require annual disking to maintain them in a vegetative-free state. If chemical compounds can be found that will be cheaper in the long run and fully as effective and will permit widening the firebreaks where needed, this would contribute toward the more complete protection of forested areas. Certain chemical compounds show promise — at least when used on certain soil and cover types, but they may not be as effective when used under other soil and cover conditions.

Cooperative work is underway in firebreak studies. The Minnesota Conservation Department, in cooperation with the Lake States Forest Experiment Station, has been providing men and equipment to lay out experimental plots and apply chemicals. Chemical companies have provided most of the test material free of charge, and company representatives have helped with problems of application. The University of Wisconsin has had an active chemical research program for a number of years. As more products are developed, more testing is needed to determine what products appear

to yield the best results when used under rigidly controlled conditions. When operational testing of these firebreak chemicals is recommended, the various forestry agencies that regularly maintain firebreaks would be in a position to provide cooperation in additional testing on a large scale. Only through this type of testing can the economics of chemical versus mechanical firebreak maintenance be determined.

Research can also help to supply answers to the question: "What type of fire detection do we need to provide the best coverage at least cost?" Some areas are well adapted to 100-percent aerial detection; others perhaps need a combination of air and ground detection, and still other areas may get the most efficient detection coverage from a network of fire towers. These are forest protection operational problems, but research may be able to help evaluate the effectiveness of different methods of detection.

Proposed Studies •

1. *Continue evaluation of new and improved fire suppression equipment.*

2. *Begin testing retardant chemicals* for limited aircraft use and extensive ground application.

3. *Continue chemical firebreak work.* Apply the results to pilot areas on various fuel types.

4. *Survey natural firebreak possibilities* with particular reference to hardwood stands breaking up plantation areas: map these areas, check on surface fuels, access, and control possibilities.

5. *Provide assistance in evaluating effectiveness of fire detection systems.*

Special Considerations and Opportunities for Cooperation

There are a number of opportunities for cooperative research in the fire control field. Fire control agencies generally want to test new equipment under local conditions before accepting them for more general application. These agencies must take the lead in testing new products and methods of fire control in local areas. Research can help design these tests and cooperate in analyzing the results.

SUPERIOR NATIONAL FOREST
SMOKEY POINTS TO FOREST FIRE DANGER TODAY!
EXTREME USE EXTREME CAUTION FIRES EXPLODE
VERY HIGH BE VERY CAREFUL FIRES BURN FIERCELY
HIGH BE CAREFUL FIRES BURN HOT
MEDIUM BE CAREFUL IT CAN GET DRY
LOW
SMOKEY
U.S.

A large percentage of forest fires in the Lake States are caused by PEOPLE. The fire prevention effort is, therefore, necessarily directed toward individuals of all ages that are potential fire starters. In the forest, informational signs can make the public aware of fire danger and burning conditions. Radio and television are excellent mediums through which to inform large numbers of people using the forested areas. And at home and school, fire prevention efforts should be directed toward the children to make them consicious of their future responsibilities toward our natural resources. (Photo at upper left courtesy of KSTP Radio, St. Paul.)

FIRE PREVENTION

Information Needed and Research Underway

Since most of the fires in the Lake States are man-caused, there is a continuing need for an aggressive fire prevention program. The present fire prevention media are good and should be continued, but new approaches are also needed. The basic components of a fire prevention program, as recognized in a California study, include (a) enforcement, (b) education, (c) engineering, and (d) environment. In this region we are particularly interested in enforcement and education and feel that if these two variables could be materially strengthened, through the efforts of both research and administration, a continued reduction of man-caused fires would be realized. Research on these phases of fire prevention must be on a cooperative basis between foresters and the branch of the social studies dealing with human behavior. Efforts now should be directed toward problem areas where the incidence of man-caused fires is high rather than toward the public in general.

One of the most perplexing of all fire control problems deals with the human aspects of forest fire prevention. The majority of man-caused fires are preventable, and a continued reduction in the number of such fires should lead to a continued reduction in area burned. More than 95 percent of the fires in the Lake States are man-caused. Lightning, the only other cause, is not a serious problem in the Great Lakes Region. The problem may be stated simply and directly: How can people be made to realize that uncontrolled fire is completely undesirable and that there is no excuse for carelessness where fire is involved?

The general approach to fire prevention, that is, mass information media, has changed only slightly in the past several years. These approaches, reasonably effective in the past, should probably be continued, but new fire prevention methods should be tried. Nationally, the Smokey Bear fire prevention program is the primary source of public information. "Keep Green" programs in many of the States supplement this effort by locally emphasizing the importance of preventing fires. These programs rely on a general message to meet the general public. They fail to concentrate on particular problem areas, groups of people, or specific risk classes. Will area closures during periods of high fire danger be understood and accepted by the general public, and can this method of fire prevention be used to reduce risk when burning conditions are extreme? In some instances, State forestry agencies have identified specific problem areas and intensified the standard prevention efforts in these areas.

The obvious should not be overlooked in preventing fires. Frequently a direct approach to a problem can be extremely productive. For example, in Wisconsin a local ranger decided to check into fires caused by debris burners. He determined that most of the fires were caused by inadequate trash burners, burners that were unable to confine the burning material. A handout was prepared showing a safe trash burner, and the proper incinerators were stocked at a local hardware store. Local people began using the safe trash burners, and the debris-burning fires were reduced to only one-sixth of what they had been. No elaborate study was needed to solve this problem, but a keen interest by the local ranger in preventing these fires *was* needed. This type of finding points up the need for a detailed analysis of fire causes — perhaps with specific reference to local areas.

What new approaches are needed in fire prevention? Where should we go from here?

A study now being conducted in California is unique in its approach to understanding the man-caused fire problem. This cooperative study between the University of California and the Pacific Southwest Forest and Range Experiment Station, U.S. Forest Service, is based primarily on the personal interview theory where questionnaires are used to bring out some aspects of fire prevention not previously studied. The areas of enforcement and education are considered the most important, and the initial effort is concentrated in this direction. Use of these two prevention components permitted limiting the scope of the project so that specific questions could be directed to groups with similar interests and backgrounds. Some of the information sought on the survey was: (1) What do people think about fire laws. (2) Why don't they obey fire laws. (3) What communication media is

most effective in reaching the public. (4) Do certain groups need more fire prevention education. and (5) what do individuals know about fire danger, fire behavior, and fire effects.

The California fire research organization has recognized, and rightly so, that foresters need outside help in developing a more effective fire prevention program. Fire prevention problems are concerned with people. The groups best trained to study and understand these people are specialists in the social studies dealing in human behavior. This cooperative study has already produced some worthwhile results — results that are helping to do a more effective job of fire prevention.

There is every reason to believe that a similar approach to the man-caused fire problem could be made here in the Lake States. Hunter problems, population pressures, and local high-risk areas are found in all three States.

Proposed Studies •

1. *Make a complete analysis of fire occurrence* during the past 10 years to determine what the major problems are and where the initial work should be concentrated. The States and Forest Service organizations have most of this information readily available, and summaries could be made that would pinpoint the problem areas.

2. *Organize a project employing specialized skills* to attack the fire prevention problems rated of highest priority in the analysis of fire occurrence.

Special Considerations and Opportunities for Cooperation

The most effective means of obtaining the specialized skills in the social sciences is through a cooperative arrangement with one of the universities in the region. The larger institutions, University of Michigan, Michigan State University, University of Wisconsin, and University of Minnesota, probably offer the best opportunity for finding scientists with interests in the fire prevention area. Forestry cooperation in financing is desirable through Conservation Departments and the U.S. Forest Service. An annual budget of $20,000 for a 3-year period is probably a minimum for a project that can be expected to contribute significantly to fire prevention practice.

PRESCRIBED BURNING

Information Needed and Research Underway

Fire has had only limited use in the Lake States for land management purposes. Yet it is well known that the early pine stands in many parts of the Lake States resulted from extensive burns. A number of possible uses of fire are presently being tested on a limited scale. These include use of fire for hazard reduction, seedbed or planting site preparation, and brush control — all important in regeneration of pine stands. Fire is also being used on limited areas to improve wildlife habitat. Economics are important in using fire. For example, if hazard reduction is needed on an area, a prescribed burn carefully executed may do the job more cheaply and efficiently than any other method. The same may be true for site preparation and control of undesirable brush and tree species. Determining where and under what conditions fire can be used is the primary research job. Applying these results to actual conditions on the ground will be a job for land managers.

Prescribed fire has been used beneficially for a number of years in many parts of the country. Most notable is the use of fire in managing southern pine. Here, the purpose is primarily hazard reduction and disease control where longleaf pine is the important species. In the Pacific Northwest prescribed fire has been used as a means of regenerating Douglas-fir, perhaps the most important commercial species in that area. There, fires provide the dual benefits of hazard reduction and seedbed preparation. In California controlled fire has application for type conversion (brushlands to grass) and for hazard reduction. In the Intermountain West, controlled fire helps reduce hazard in

Prescribed burning on experimental plots shows promise in removing competing brush and vegetation so that adequate tree regeneration may be obtained after a harvest cut. Burning is done under a specific set of weather conditions to insure an adequate burn with a minimum of damage to the residual stand.

Prescribed burning in clearcut areas has the dual objectives of reducing the hazard of a wildfire and preparing the seedbed or planting site. Large blocks of slash may be successfully burned when litter fuels are dry and the larger branchwood is relatively low in moisture content.

Heavy slash has been disposed of by burning on this area. By controlled burning, damage to adjacent timber stands has been prevented. Direct seeding or machine planting may now be done at a relatively low cost with an excellent chance of seedling survival. Erosion is not a problem on flat or gently sloping areas such as this, and the material remaining on the ground provides some protection to the seedlings.

the heavier fuel types, prepare seedbeds, and control white pine blister-rust. Some use is also made of prescribed fire for converting sagebrush range to grassland. In the Lake States, prescribed burning has not been widely accepted, and operational use of prescribed fire has been limited to local areas. Probably this reluctance is partly due to memories of past fires that caused some major disasters in the Lake States region. Many of the historical fires causing widespread destruction originated as debris-burning or land-clearing fires. These fires are still linked in the public mind to the proposed intentional use of fire for land management purposes.

Another reason why fire has not been widely used during the past 20 to 30 years is that the forests of the Lake States have been "growing" forests, not "cutting" forests as they were around the turn of the century. This means that only a minor amount of slash and debris has been accumulating in comparison to the volume of material that resulted from the pine cuttings in the early 1900's. We are again entering on a period of increased logging activity, which will create large areas of logging debris. During severe fire weather, these large areas, if not properly treated, can cause fires that are difficult or impossible to control. In most forested areas, conifer slash is considered one of the most hazardous of all fuel types. The rate of spread is high, and this fuel material burns fiercely. To meet this situation, an active prescribed burning research program should be activated to find out where and when fire can be used to achieve established land management objectives.

Current prescribed burning research in the Lake States has been primarily concerned with seedbed preparation, hazard reduction, brush eradication, and wildlife habitat improvement. More attention could be directed toward each of these plus other fire-effect studies. Prescribed burning is a means to an end and not an end in itself. The *effects* of the prescribed fire are what are important.

Fire of practically any intensity burning in any fuel type has some measurable effect. This effect may vary from a condition where only a small amount of dead surface material is removed and is replaced in a short period of time to a condition where large volumes of heavy material are consumed, all living vegetation is killed, and the soil mantle is at least temporarily damaged. The effects of repeated wildfire can be so severe and widespread that natural tree succession may not be possible for an extended period. On the other hand, beneficial effects of fire are becoming better recognized in many parts of the country. These beneficial effects usually result from using fire under prescribed, controlled conditions — seldom does a wildfire produce beneficial results.

Three major fire-effects studies are presently underway in the Lake States. Each study has a different goal, yet all are concerned with the effects of fire on a specific forest type. Ecological succession is the special interest in one study while natural regeneration and brush removal are primary considerations in the other studies. In all cases, though, any burn that is successfully completed must be carefully inspected to determine the effects of fire on residual fuel, plant cover, residual stand, and exposure of mineral soil. The three studies are described more fully below.

Two areas near Grand Rapids, Minn., are being used to study the effects of prescribed fire on brush mortality, soil characteristics, and growth of the residual stand. The Lake States Forest Experiment Station is conducting spring, summer, and fall burning yearly and at specified intervals to determine which applications appear to be the most satisfactory from the standpoint of producing desired results. If fire can be economically and effectively used to reduce the understory brush competition that frequents these northern Minnesota red pine sites, a major step will be achieved toward better management of these stands and more effective regeneration when the final harvest cuts are made. Soil fertility may actually be improved with periodic light burning, and tree growth may also show an increase. These possibilities are receiving major consideration in the Grand Rapids studies. Experience to date indicates that summer fires are not only easier to control but, if fuel conditions are right, produce the best kill of brush species and expose more mineral soil for natural regeneration.

Under the sponsorship of the Quetico-Superior Wilderness Research Center (and under the direction of C. E. Ahlgren), the effects of fire on

soil and various forms of plant and animal life are being investigated. This study has included observations and measurements on many old burns in various fuel types to determine the ecological successions that develop on these particular areas. More recently an area has been logged and prepared for prescribed burning. On this burn, which was completed in spring 1961, a study will be made to define the conditions under which the fire burned and the ultimate effects of the fire on reproduction, plant succession, and physical-chemical characteristics of the soil. While much of this work is concerned with forest fires in wilderness areas, many of the findings will be directly applicable to other areas as well.

The Ford Forestry Center at L'Anse, Mich., has been sponsoring research to determine if fire can be used to regenerate jack pine following logging. Here research is aimed at finding out more about the thermal characteristics of jack pine cones and trees. Experiments are designed to first, simulate logging conditions in which a specified number of seed trees are left, and second, burn these areas under prescribed conditions of weather and fuel moisture to release the seed from cones on the seed trees. Successful regeneration of the stand is dependent upon the establishment and survival of seedlings on a mineral soil seedbed. Several areas have been successfully treated in this manner.

There are some additional areas where prescribed burning research is badly needed. One is on the use of controlled fire in removing brush and low-quality hardwoods from the thousands of acres of good pine site previously occupied by pine stands. If fire could be used to prepare these sites economically for planting, this would be an outstanding contribution to Lake States forestry knowledge. Site preparation is presently one of our most expensive forestry practices because of the necessity of using heavy equipment. Fire may provide a solution to this problem.

Proposed Studies •

1. *Investigate the operational use of fire or techniques of doing the burning job.* Each fire presents a different burning situation. When burning under the more severe weather conditions, there is a smaller margin for error in designing firing patterns and in planning control effort. Also, areas scheduled for burning require different approaches depending on size and shape of area, prevailing weather, fuel volume and composition, and available control forces. In this study, the main role of research would be to develop sure techniques for controlling prescribed burns, provide evidence of successful control, and thus help build confidence in the minds of land managers concerning the controlled use of fire.

2. *Study the use of fire to improve wildlife habitat.* Under certain conditions fire can be used effectively to either make more food available or help create conditions that are more desirable from a cover standpoint — both important factors in areas having unusually heavy hunting pressures.

3. *Find out how best to use fire on brush-covered sites* to prepare them for planting.

Special Considerations and Opportunities for Cooperation

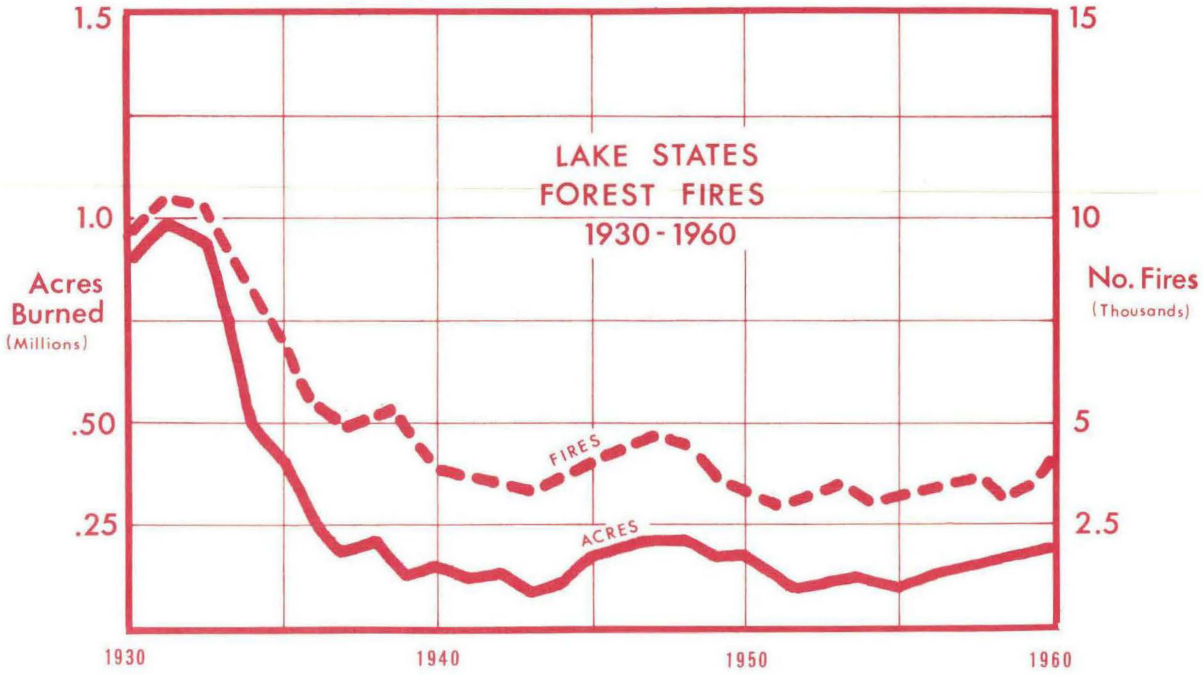
Prescribed burning offers perhaps the best possibilities for cooperative research of any of the projects so far mentioned. Nearly all agencies are holding some land on which small-scale burning experiments could be conducted. On some game refuges fire is being used to reduce the hazard where fire risk is unusually high.

The fire-behavior training aspects of prescribed burning should not be overlooked as an important fringe benefit of using controlled fire for land management purposes. These fires can provide an opportunity for suppression crews to work together as a team, and new equipment and materials may be tested under actual fire conditions. Inexperienced fire control personnel are able to observe fire behavior characteristics that otherwise could be seen only on a wildfire. This experience prepares these individuals for more effective service on going fires.

SIZE OF THE FIRE RESEARCH JOB

It is quite evident that the present level of fire research effort is inadequate for more than a token attack on the problems outlined in this report. Opportunities for initiating new work and supplementing existing research need to be pursued vigorously. Only two men in the entire Lake States region now spend full time on fire research and one of these was employed within the past year. Research at the universities is dependent on assistance through cooperative financing now available in an insignificant amount.

Improvement on both fronts is called for. A stronger force of full-time researchers is needed. Three or four men in each of the areas of crown fire research, fire prevention research, and prescribed burning research would provide continuity and strength. Funds for employment of at least two graduate students in each area would make use of specialized skills available at the universities and promote training of the specialists necessary for significant progress in so much of the modern technology. A research program of this magnitude, including a full-time staff of well-trained scientists and part-time training projects emphasizing special skills, would bring to the Lake States what it has never had before, a fire research effort commensurate with the complex problems that remain to be solved.



Forest fires and acreage burned in the Lake States showed a marked decrease in the thirties. Since about 1940 no significant changes have occurred.

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